

UNCLASSIFIED

AD NUMBER

ADA954924

CLASSIFICATION CHANGES

TO: UNCLASSIFIED

FROM: CONFIDENTIAL

LIMITATION CHANGES

TO:

Approved for public release; distribution is
unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies
and their contractors;
Administrative/Operational Use; 22 MAR 1945.
Other requests shall be referred to Watertown
Arsenal Laboratory, MA 02172.

AUTHORITY

31 Mar 1957, DoDD 5200.10; Wal per DTIC form 55

THIS PAGE IS UNCLASSIFIED

710/732
EX-
Copy 2.2
C E C 1012
710/732

AD-A954 924

UNCLASSIFIED



WATERTOWN ARSENAL
LABORATORY

MEMORANDUM REPORT

NO. WAL 710/732

Resistance of Various Plastic Laminates, Made by Victory Plastics Co.,

to Perforation by Fragment-Simulating Projectiles

This document has been approved
for public release and sale; its
distribution is unlimited.

Revised
of C
in C
SAC 1
15 Aug 1956
FILE COPY

Unclassified

BY
J. F. SULLIVAN
Asst. Engineer

ATT-126223
ATT-126223

DTIC
ELECTED
AUG 13 1965
SD

UNCLASSIFIED

DATE 22 March 1945

WATERTOWN ARSENAL
WATERTOWN, MASS.

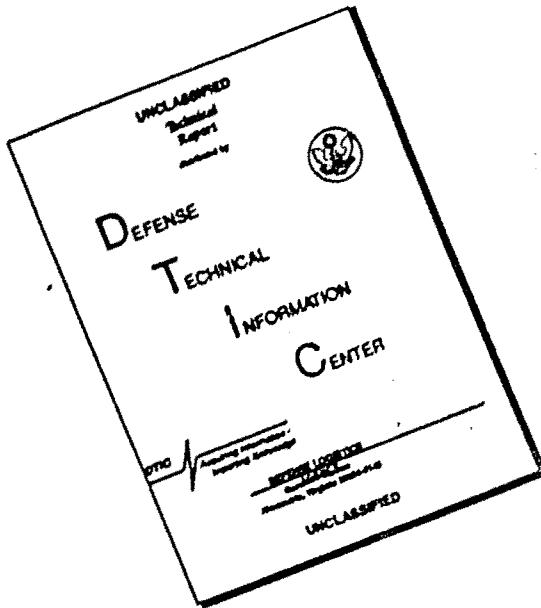
Form No. SP008-38
L 18 July 1944

SECURITY INFORMATION

188-14

8 9 035

DISCLAIMER NOTICE



**THIS DOCUMENT IS BEST
QUALITY AVAILABLE. THE COPY
FURNISHED TO DTIC CONTAINED
A SIGNIFICANT NUMBER OF
PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**

Accession For

NTIS GRA&I

DTIC TAB

Unannounced

Justification

By _____

Distribution/ _____

Availability Codes

Dist	Avail and/or Special
------	-------------------------

A1

~~UNCLASSIFIED~~

UNCLASSIFIED

WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT NO. WAL 710/732

Partial Report on Problem B-8.14

22 March 1945

Resistance of Various Plastic Laminates, Made by Victory Plastics Co.,
to Perforation by Fragment-Simulating Projectiles

1. In response to a request from the Office, Chief of Ordnance¹, a program was conducted at this arsenal to develop improved components of body armor assemblies. In accordance with a request of the Boston Ordnance District², tests have been conducted here on samples of plastic laminates made by the Victory Plastic Company. Inasmuch as such materials have been considered as components of body armor assemblies it is considered desirable to report the results of these tests as part of the general development program.

2. None of the materials submitted exhibited resistance to perforation by fragment-simulating projectiles equivalent to that afforded by samples of Doron³ tested earlier. The smallness of most samples did not allow quantitative comparison of the various samples.

3. After determination of its weight-per-unit-area, each sample was rigidly clamped to an appropriate frame which allowed the areas of impact to be free of support from the rear. Into these areas were directed impacts of cal. .45 steel-jacketed projectiles or cal. .30 fragment-simulating projectiles, G-1-S,⁴ or cal. .22 fragment-simulating projectiles, G-2,⁵ depending upon the size of the sample and the availability of the projectiles. On the basis of weight-per-unit-area a standard of required resistance was established for each sample by reference to the earlier tests of Doron. Since the extreme smallness of many of the samples made the determination of ballistic limits

1. O.O. 422.3/71(c) - Wtn 470.5/7443(c), 28 September 1943.
2. BTN 160/3954/47482 - Wtn 400.112/3722, 14 December 1944.
3. WAL 710/641, 25 May 1944.
4. WAL 762/247(c), 17 December 1943.
5. WAL 762/253(c), 7 January 1944.

UNCLASSIFIED

impossible, charges calculated to give the required velocity were prepared and fired, and the resistance of the sample was thus determined qualitatively. The results of the tests are recited in Table I.

4. Although this method did not allow an absolute evaluation of the many samples submitted, it did provide, in most cases, a basis on which a decision as to whether or not the material was better than materials already in use could be made. On this basis, therefore, it can be said that all materials submitted, with the exception of samples 101944A, 103144A, 11344A, 11545A, appeared to be inferior in resistance to perforation by fragment-simulating projectiles to materials tested previously. Of these exceptions the status of sample 11344A alone has been quantitatively determined. This sample appeared to afford resistance to the cal. .45 projectile substantially equivalent to that of Dron. The results on the other three exceptions were such as to preclude any definite decision as to their merits.

5. Results of tests conducted on various materials in the past have indicated a lack of correlation between the relative resistance of different materials under test with fragment-simulators and their relative resistance to perforation by fragments of a high-explosive shell statically detonated in close proximity to the samples. Such indications caution against extrapolation of ballistic limit test results to service conditions. It is recognized that the only valid test currently employed to reflect service conditions is an actual fragmentation test. Ballistic limit tests such as those performed during this program have a valid role in that they can determine the control being exercised by the manufacturer in a continuous or repetitive process of fabricating a material which has previously established its resistance efficiency in an actual fragmentation test. Within certain limitations they also may be used to determine the probable resistance to actual fragmentation of a novated version of a material whose resistance has already been established. They should never be used, however, as a basis for determining the merits of a material which, either in itself or in some similar form, has not previously been tested.

6. Since the materials used in the subject tests are for the most part modifications of materials tested earlier, it is believed that the use of fragment-simulators as determinants of the merits of these materials has been legitimate. The next step would appear to be the fabrication of enough samples of the type 11344A to allow an actual fragmentation test. From the results of the subject tests no other samples appear to warrant the additional expenditure of time, manpower, materials and money which such a test requires.



J. F. Sullivan
Asst. Engineer

APPROVED:



E. L. REED
Research Metallurgist
Acting Chief, Armor Section

SECURITY INFORMATION

- 2 -

CONFIDENTIAL

Table I

Summary of Ballistic Tests Conducted on Samples of Plastic Laminates

D.A. C. Laboratory Plastics Co.

Make-Up of Sample	Sample size weight steel (Grams)	Ballistic Limit		
		Sample size weight steel (Grams)	Req. act.	Req. act.
11 ply Fiberglass EOC-11-164 coated with 6B Nylon. 11 Ply Hi/ten Rayon 2 oz. alternate layers. Coated with 63 Nylon solution, molded at 1500 lbs. per sq. in. for 15 min. at 320 F.	11" x 2 1/4"	25.0	.025"	760 <975
14 ply Fiberglass EOC-11-164 coated with 6B Nylon. 14 ply Nylon 6 oz. alternate layers, coated with 6B Nylon, molding pressure 1500 lbs. per sq. in. for 45 min. at 320 F.	11" x 2 1/4"	16.0	.017"	1120 <860
14 ply Fiberglass EOC-11-164 coated with 6B Nylon. 14 ply Hi/ten Rayon 2 oz. alternate layers coated with 6B Nylon, molding pressure 1500 lbs. per sq. in. for 30 min. at 320 F.	11" x 2 1/4"	22.0	.024"	860 775+70
15 ply Fiberglass EOC-11-164 coated with 6B Nylon. 8 ply Hi/ten Rayon 2 oz. alternate layers in back of sample, coated with 6B Nylon. Molding pressure 1500 lbs. per sq. in. for 30 min. at 310 F.	11" x 2 1/4"	18.0	.011"	1000 <865
15 ply Fiberglass EOC-11-164 coated with 6B Nylon. 6 ply Nylon 6 oz. alternate layers in back portion of sample. Coated with 6B Nylon, molding pressure 1000 lbs. per sq. in. for 30 min. at 320 F.	11" x 2 1/4"	17.0	.011"	1000 <855
15 ply Fiberglass EOC-11-164 coated with 6B Nylon. 8 ply Hi/ten Rayon 2 oz. alternate layers in back portion of sample. Coated with 6B Nylon, molding pressure 1000 lbs. per sq. in. for 30 min. at 320 F.	11" x 2 1/4"	16.0	.010"	960 <855
14 ply Fiberglass EOC-11-164. Both fabrics coated with Gelva 15. 1-1/2" x 1/2" alternate layers. Molding pressure 1500 lbs. per sq. in. for 30 min. at 320 F.	11" x 2 1/4"	25.0	.016"	1300 <915
14 ply Fiberglass EOC-11-164. Both fabrics coated with Gelva 15. 1-1/2" x 1/2" alternate layers. Molding pressure 1500 lbs. per sq. in. for 30 min. at 320 F.	11" x 2 1/4"	27.0	.014"	1000 890+80

Coated with Gelsva-15. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102543 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102544 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 100 lbs. per sq. in. for 30 min. at 320 F.

102743 14 Ply Fiberglass ECO-11-164. Heated in oven 2-3/4" x 2-3/4" x 1/4" 2 hrs. at 40C F. and coated with FB Nylon. Molding pressure 300 lbs. per sq. in. for 30 min. at 320 F.

102744 Same as 102743, except the Fiberglass was not heat treated and the molding pressure reduced to 150 lbs. per sq. in.

102745 Same as 102743 except the molding pressure was reduced to 125 lbs. per sq. in.

102746 Same as 102745 and C except the molding pressure was increased to 200 lbs. per sq. in. 14 Ply Fiberglass ECO-11-164. No neat treatment. 14 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 250 lbs. per sq. in. for 30 min. at 320 F.

102747 Same as 102746 except the molding pressure was reduced to 150 lbs. per sq. in.

102914 17 Ply Fiberglass X-1551. 17 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F.

103144 Same as 103143 except molding pressure was reduced to 250 lbs. per sq. in.

103145 3 Ply Duck (C.O.C.L.). 4 Ply Cerlite II H5. alternate layers, molding pressure 300 lbs. per sq. in. for 15 min. at 320 F.

103146 5 Ply Duck (C.O.C.L.). 5 Ply Vinylite alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F. (10.004").

103147 Same as 103146 except 3 plies of each were used in place of alternate layers of 5 each.

11344 25 Ply Fiberglass X-1551. 25" Vinylite (C.O.C.L.) alternate layers, molding pressure 650 lbs. per sq. in. for 30 min. at 320 F.

11345 22 Ply Fiberglass X-1551. 22 Ply Vinylite 7.5" x 7.5" 350 .047" 1065 1000

Coated with Gelsva-15. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102543 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102544 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 100 lbs. per sq. in. for 30 min. at 320 F.

102743 14 Ply Fiberglass ECO-11-164. Heated in oven 2-3/4" x 2-3/4" x 1/4" 2 hrs. at 40C F. and coated with FB Nylon. Molding pressure 300 lbs. per sq. in. for 30 min. at 320 F.

102744 Same as 102743, except the Fiberglass was not heat treated and the molding pressure reduced to 150 lbs. per sq. in.

102745 Same as 102743 except the molding pressure was reduced to 125 lbs. per sq. in.

102746 Same as 102745 and C except the molding pressure was increased to 200 lbs. per sq. in. 14 Ply Fiberglass ECO-11-164. No neat treatment. 14 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 250 lbs. per sq. in. for 30 min. at 320 F.

102747 Same as 102746 except the molding pressure was reduced to 150 lbs. per sq. in.

102914 17 Ply Fiberglass X-1551. 17 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F.

103144 Same as 103143 except molding pressure was reduced to 250 lbs. per sq. in.

103145 3 Ply Duck (C.O.C.L.). 4 Ply Cerlite II H5. alternate layers, molding pressure 300 lbs. per sq. in. for 15 min. at 320 F.

103146 5 Ply Duck (C.O.C.L.). 5 Ply Vinylite alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F. (10.004").

103147 Same as 103146 except 3 plies of each were used in place of alternate layers of 5 each.

11344 25 Ply Fiberglass X-1551. 25" Vinylite (C.O.C.L.) alternate layers, molding pressure 650 lbs. per sq. in. for 30 min. at 320 F.

11345 22 Ply Fiberglass X-1551. 22 Ply Vinylite 7.5" x 7.5" 350 .047" 1065 1000

Coated with Gelsva-15. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102543 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 200 lbs. per sq. in. for 30 min. at 320 F.

102544 14 Ply Fiberglass ECO-11-164. Both fabrics coated with Gelsva-15. 14 Ply 5/ten Rayon 2 oz. alternate layers. Molding pressure 100 lbs. per sq. in. for 30 min. at 320 F.

102743 14 Ply Fiberglass ECO-11-164. Heated in oven 2-3/4" x 2-3/4" x 1/4" 2 hrs. at 40C F. and coated with FB Nylon. Molding pressure 300 lbs. per sq. in. for 30 min. at 320 F.

102744 Same as 102743, except the Fiberglass was not heat treated and the molding pressure reduced to 150 lbs. per sq. in.

102745 Same as 102743 except the molding pressure was reduced to 125 lbs. per sq. in.

102746 Same as 102745 and C except the molding pressure was increased to 200 lbs. per sq. in. 14 Ply Fiberglass ECO-11-164. No neat treatment. 14 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 250 lbs. per sq. in. for 30 min. at 320 F.

102747 Same as 102746 except the molding pressure was reduced to 150 lbs. per sq. in.

102914 17 Ply Fiberglass X-1551. 17 Ply Vinylite (C.O.C.L.) alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F.

103144 Same as 103143 except molding pressure was reduced to 250 lbs. per sq. in.

103145 3 Ply Duck (C.O.C.L.). 4 Ply Cerlite II H5. alternate layers, molding pressure 300 lbs. per sq. in. for 15 min. at 320 F.

103146 5 Ply Duck (C.O.C.L.). 5 Ply Vinylite alternate layers, molding pressure 500 lbs. per sq. in. for 30 min. at 310 F. (10.004").

103147 Same as 103146 except 3 plies of each were used in place of alternate layers of 5 each.

11344 25 Ply Fiberglass X-1551. 25" Vinylite (C.O.C.L.) alternate layers, molding pressure 650 lbs. per sq. in. for 30 min. at 320 F.

11345 22 Ply Fiberglass X-1551. 22 Ply Vinylite 7.5" x 7.5" 350 .047" 1065 1000

11545A	sq. in. for 30 min. at 310 F. (150 C.)	7-1/8" x 7-1/2"	.262	.277	.350 <509	--	--	--	--	--
11545B	Same as 11545A except 3 plies of each were used in place of alternate layers of $\frac{1}{2}$ each.	7-1/8" x 7-1/2"	.262	.277	.350 <509	--	--	--	--	--
11545C	25 ply Fiberglass X-15-1. 25" Vinylite (0.004") alternate layers. molding pressure 650 lbs. per sq. in. for 30 min. at 320 F.	7-1/8" x 7-1/2"	.262	.277	.350 <509	--	--	--	--	--
11545D	22 ply Fiberglass X-1551. 22 ply Vinyllite (0.004") alternate layers. Molding pressure 500 lbs. per sq. in. for 30 min. at 320 F.	7-1/8" x 7-1/2"	.262	.277	.350 <509	--	--	--	--	--
11545E	21 ply Fiberglass EOC-128-38. 21 ply Butvar (0.015") alternate layers. Molding pressure 650 lbs. per sq. in. for 15 min. at 310 F.	7-1/8" x 7-1/2"	.262	.277	.350 <509	--	--	--	--	--
11545F	40 ply Fiberglass EOC-128-38 coated with 12% Tg9 P.V. Butvar on both sides. Penetration complete. Molding pressure 500 lbs. per sq. in. for 30 min. at 275 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545G	23 ply Fiberglass EOC-128-38. 23 ply Duran screen (Velon) alternate layers. Molding pressure 500 lbs. per sq. in. for 35 min. at 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545H	24 ply Fiberglass EOC-128-38. 2 poly Styrene (H.V.) alternate plies of styrene between the 17th and 18th ply of Fiberglass. Molding pressure 500 lbs. per sq. in. for 30 min. at 270 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545I	20 ply Fiberglass EOC-128-38. 2 poly Emery cloth No. 40. 21 ply Butvar (0.015"). Emery cloth placed in alternate layers starting from the 14th ply of Butvar and Fiberglass. Molding pressure 250 lbs. per sq. in. for 30 min. at 280 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545J	22 ply X-1551 Fiberglass coated with a vinyl dispersion. Molding pressure 500 lbs. per sq. in. for 10 min. at 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545K	15 ply X-1551 Fiberglass coated with a vinyl dispersion. 7 poly styrene coated with a vinyl dispersion. 15 alternate layers in center portion of sample. Molding pressure 250 lbs. per sq. in. for 5 min. at 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545L	19 ply X-1551 Fiberglass coated with vinyl dispersion. 9 poly Butvar (0.005") alternate layers in center portion of sample. molding pressure 250 lbs. per sq. in. for 10 min. At 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545M	Same as 11545A except the molding pressure was reduced to 120 lbs. per sq. in. for 5 min. at 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--
11545N	20 ply X-1551 Fiberglass - no coating. Butvar (0.005") alternate layers; molding pressure 100 lbs. per sq. in. for 5 min. at 340 F.	8" x 2"	.252	.264	.350 <509	--	--	--	--	--

Molding pressure 1000 lbs. per sq. in. for 10 min. for 30 min. at 280 F.

115454 22 ply X-1551 Fiberglass coated with vinyl dispersion. Molding pressure 500 lbs. per sq. in. for 10 min. at 340 F.

115453 15 ply X-1551 Fiberglass coated with a vinyl dispersion. 7 ply rayon coated with a vinyl dispersion alternate layers in center portion of sample. molding pressure 250 lbs. per sq. in. for 5 min. at 340 F.

115455 19 ply X-1551 Fiberglass coated with vinyl dispersion. 3 ply rayon (0.005") alternate layers in center portion of sample; molding pressure 250 lbs. per sq. in. for 10 min. at 340 F.

115456 Same as 115454 except the molding pressure was reduced to 100 lbs. per sq. in. for 5 min. at 340 F.

115457 20 ply X-1551 Fiberglass - no coating. 12 plies rayon (0.005") alternate layers of molding pressure 1000 lbs. per sq. in. for 30 min. at 340 F.

124453-1 22 ply X-1551 Fiberglass, coated with vinyl dispersion. Molding pressure 600 lbs. per sq. in. for 2 hr. at 340 F.

124453-2 " " " "

124453-3 " " " "

124453-4 Same as 124453 except molding pressure was increased to 800 lbs. per sq. in.

124453-5 " " " "

124453-6 " " " "

124453-7 Same as 124453 and 3 except molding pressure was increased to 1000 lbs. per sq. in.

124453-8 " " " "

124453-9 " " " "

124453-10 " " " "

124453-11 " " " "

1. Cal. #5 steel-jacketed mold projectile - 200 grains

2. Cal. #3 fragment-simulation projectile - 14 grains

3. Cal. #2 fragment-simulation projectile - 17 grains

CONFIDENTIAL

Molding pressure 1000 lbs. per sq. in. for 10 min. at 280 F.

115454 22 ply X-1551 Fiberglass coated with vinyl dispersion. Molding pressure 500 lbs. per sq. in. for 10 min. at 340 F.

115453 15 ply X-1551 Fiberglass coated with a vinyl dispersion. 7 ply rayon coated with a vinyl dispersion alternate layers in center portion of sample. molding pressure 250 lbs. per sq. in. for 5 min. at 340 F.

115455 19 ply X-1551 Fiberglass coated with vinyl dispersion. 3 ply rayon (0.005") alternate layers in center portion of sample; molding pressure 250 lbs. per sq. in. for 10 min. at 340 F.

115456 Same as 115454 except the molding pressure was reduced to 100 lbs. per sq. in. for 5 min. at 340 F.

115457 20 ply X-1551 Fiberglass - no coating. 12 plies rayon (0.005") alternate layers of molding pressure 1000 lbs. per sq. in. for 30 min. at 340 F.

124453-1 22 ply X-1551 Fiberglass, coated with vinyl dispersion. Molding pressure 600 lbs. per sq. in. for 2 hr. at 340 F.

124453-2 " " " "

124453-3 " " " "

124453-4 Same as 124453 except molding pressure was increased to 800 lbs. per sq. in.

124453-5 " " " "

124453-6 " " " "

124453-7 Same as 124453 and 3 except molding pressure was increased to 1000 lbs. per sq. in.

124453-8 " " " "

124453-9 " " " "

124453-10 " " " "

124453-11 " " " "

124453-12 " " " "

124453-13 " " " "

124453-14 " " " "

124453-15 " " " "

124453-16 " " " "

124453-17 " " " "

124453-18 " " " "

124453-19 " " " "

124453-20 " " " "